



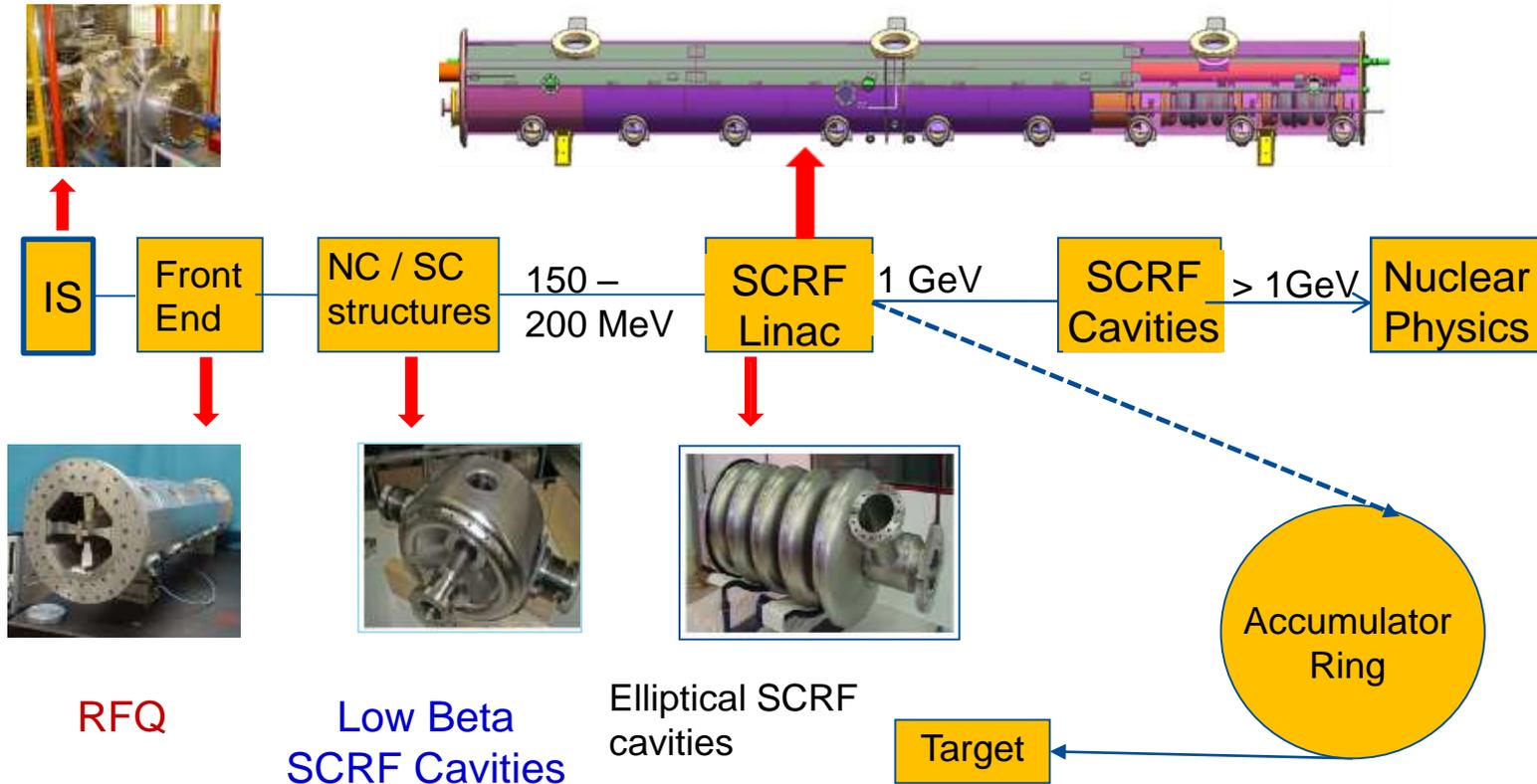
**RRCAT**



# SRF Infrastructure at RRCAT

Satish Chandra Joshi, RRCAT  
PIP-II Collaboration Meeting  
9-10 November 2015

# Proposed ISNS Facility



The SRF infrastructure to support : **ISNS activity** and  
**Participation in IIFC related activities**

# SRF Infrastructure facilities

## Cavity fabrication & inspection facility



Cavity Forming Facility



15 kW EBW Machine



3D CMM



Optical Inspection Bench

## Material Characterization facility



SIMS Facility



Universal Testing Machine



Laser scanning confocal microscope

# SRF Infrastructure facilities

## SCRF Cavity Processing Facilities



Barrel Polishing Machine



Electropolishing Setup



High Pressure Rinsing Setup



Ultrasonic cleaner



High Vacuum Annealing Furnace



Cavity polished & processed

# Buildings for SCRF Cavity Development

## SCRF Cavity Fabrication & Processing Building



## SCRF Cavity Test Building (for VTS & HTS and Helium Plant)



# Cavity Forming Facility



Forming of half-cell for 650 MHz cavity

# Machining facility

## Hollow Spindle Lathe



Spindle Through Bore-210mm,  
Swing-over bed Dia.-1000 mm  
Accuracies - 10  $\mu$ m



Die-Punch assembly for  
650 MHz cavities

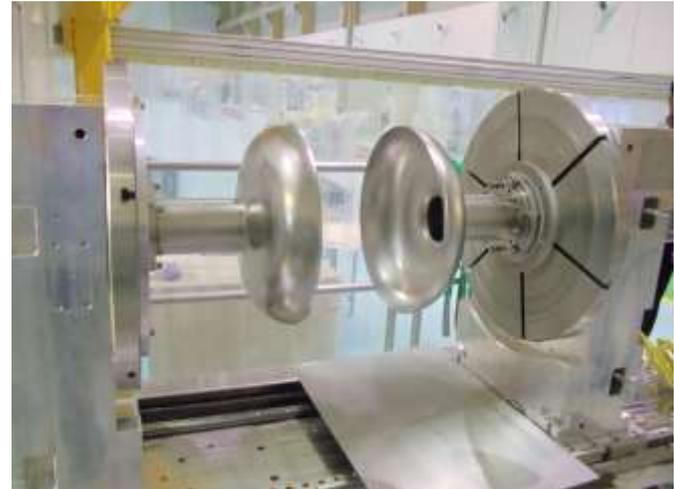
# Cavity Fabrication Facility

## Electron Beam Welding Machine

Beam power	15 kW
Gun Voltage	90 to 150 kV
Duty cycle	100%
Beam current range	0 - 100 mA or wider
Beam current setting resolution	0.1 mA
Beam oscillations	1 – 1000 Hz or more
Beam focus diameter	0.25 mm
Inner size of chamber	3650 x 1500 x 1800 mm <sup>3</sup>
X-Y table size	1780 m x 710 mm
Vacuum ready pressure	< 1x10 <sup>-4</sup> mbar in 15 min
Ready for welding pressure	< 1x10 <sup>-6</sup> mbar in 60 min



# Welding of single-cell 650 MHz cavity



# Cavity Fabrication Facility

## Nd-YAG laser beam welding facility – for 1.3 GHz single-cell cavity



A novel technique of fabrication of SRF cavities using Nd-YAG laser welding process, has been developed at RRCAT. The process has received patent from Japan.

A 1.3 GHz single-cell cavity fabricated using the facility was processed and tested at Fermilab. The cavity produced an accelerating gradient  $> 31$  MV/m

# SRF Cavity Inspection Facility

## 3D CNC Coordinate Measuring Machine

### Applications :

Dimensional inspection of SRF cavity components like half cells, dumb-bells, multi-cells etc

### Accuracy :

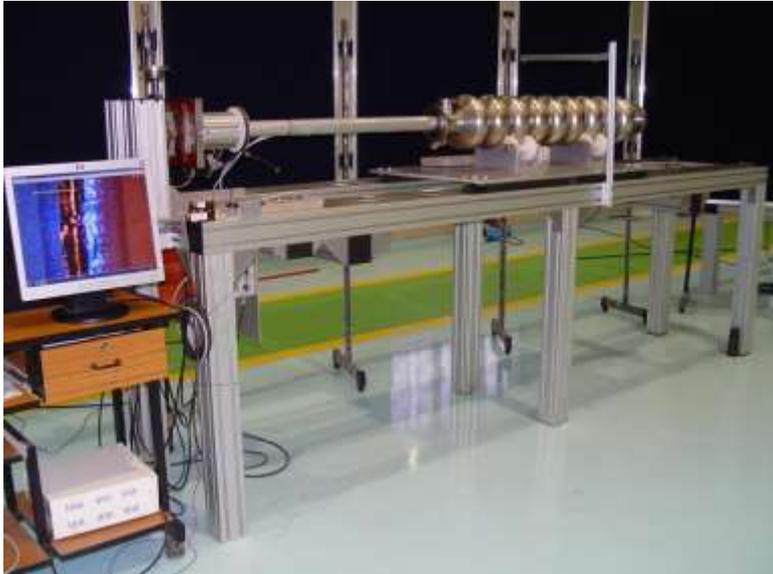
$1.6 + L/400$  microns



Inspection of machined components

# SRF Cavity Inspection Facility

## Optical Inspection Bench

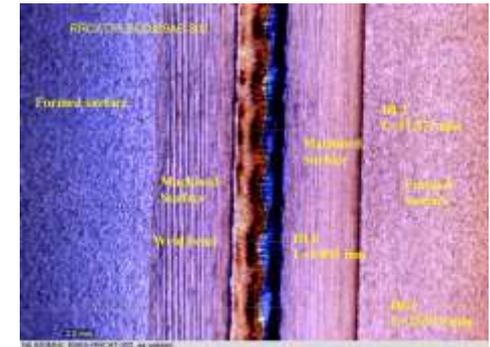
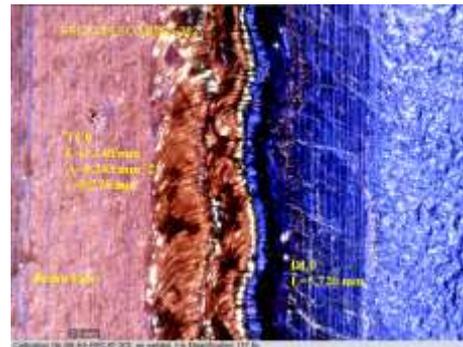


Inspection of five-cell 1.3 GHz cavity



Inspection of single-cell 650 MHz cavity

- Cavity internal surface measurement using a digital CCD camera with 10X-200X magnification.
- Tri-color LED for illumination
- Smallest measurable feature size : 10 microns

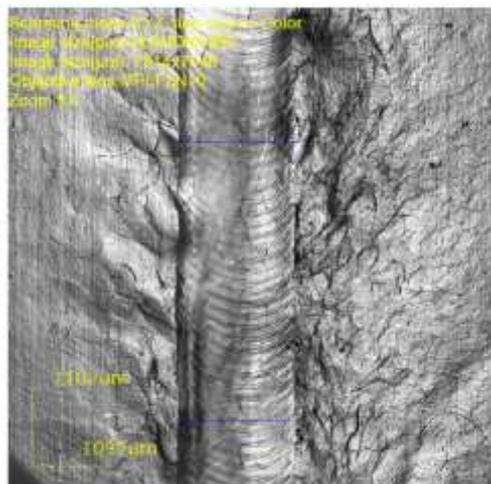


Images from optical bench (650 MHz cavity)

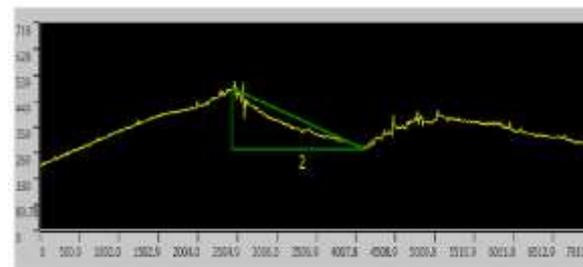
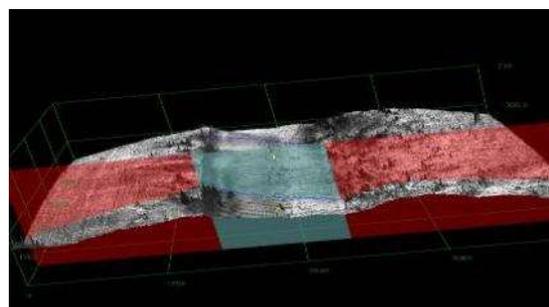
# SRF Cavity Inspection Facility

## Laser Scanning Confocal Microscope

<b>Imaging Method</b>	3-D Laser Scanning Confocal system
<b>Z - Resolution (Depth)</b>	1 nm
<b>Z - Measurement repeatability</b>	12 nm
<b>X-Y Resolution</b>	0.12 $\mu\text{m}$



Confocal image of replica



No.	Result	Width[ $\mu\text{m}$ ]	Height[ $\mu\text{m}$ ]	Length[ $\mu\text{m}$ ]
<input checked="" type="checkbox"/>	1	1806.831	252.657	1824.410
<input checked="" type="checkbox"/>	2	1689.145	212.954	1702.516

Measurement of bead profile

# SRF Cavity Material characterization Facility

## Secondary Ion Mass Spectrometer (SIMS)

To develop understanding of impurity distribution near the top layer (~100 -200 nm) of niobium by 2-D, 3-D ion mapping of the impurities.

Quantification of the elemental impurity distribution using niobium standards.

Analysis Gun :  $\text{Bi}^+$  at 30 kV  
 $\text{C}_{60}$  at 20 kV

Sputter Gun :  $\text{Cs}^+$  ; 0-2 kV  
 $\text{O}_2^+$  ; 0-2 kV  
 $\text{Xe}^+$  ; 0-2 kV  
 $\text{Ar}^+$  ; 0-2 kV



*"Study of impurity distribution in chemically treated and high pressure rinsed pure Niobium samples for SRF cavity applications using TOFSIMS technique",  
A. Bose and S. C. Joshi , Superconductor Science and Technology, July 2015*

# Cavity Processing Facility

## Centrifugal Barrel Polishing (five-cell 650 MHz cavity)

### Main features of CBP machine

- Turret speed – 0 – 200 rpm ( variable )
- Barrel speed – 0 – 200 rpm ( variable )
- Machine size – 4 m X 5 m X 3 m
- Temperature is maintained by closed loop air conditioner



Barrel Polishing Machine at RRCAT

# Cavity Processing Facility

## Electropolishing setup for 1.3 GHz & 650 MHz Cavities



**Electropolishing of nine-cell  
1.3 GHz cavity**



**Electropolishing of single-cell  
650 MHz cavity**

# Thermal Processing Facility



**High Vacuum Annealing Furnace**

## Specification of High Vacuum Furnace

Orientation	Horizontal
Maximum Temperature	1400°C Max
Working Vacuum	<1 x 10 <sup>-7</sup> mbar (600°C -1000°C ) <1 x 10 <sup>-6</sup> mbar (> 1000°C)
Working Volume	Dia : 825 mm Depth :1500 mm



**Single-cell 650 MHz cavity prepared for annealing**

# Cavity Processing Facility

## High Pressure Rinsing Setup

### Features:

Rotational speed: 2-20 RPM

Stroke: 1300 mm

Vertical speed: 50-250  
mm/min

Pressure: 80 – 100  
bar



## Ultra Pure Water Plant



UPW generation rate – 600 lph

Upgradation of ultra pure water generation plant and high pressure pumps is in process

# Pilot Cleanroom Facilities

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Pilot Class-100 clean room facility

# SRF Cavity Tuning Machine

## Tuning Setup of SRF Cavity

Separate Semi-automatic tuning facility for 1.3 GHz and 650 MHz cavities (under development)



Semi-automatic tuning facility

# Cryogenic facility

- ✓ One Helium liquefier with a liquefaction capacity of 50 l/h.
- ✓ One Helium liquefier with a liquefaction capacity of 145 l/h



**Liquid Dewar 10,000 liters and Cold Box: LR 280**



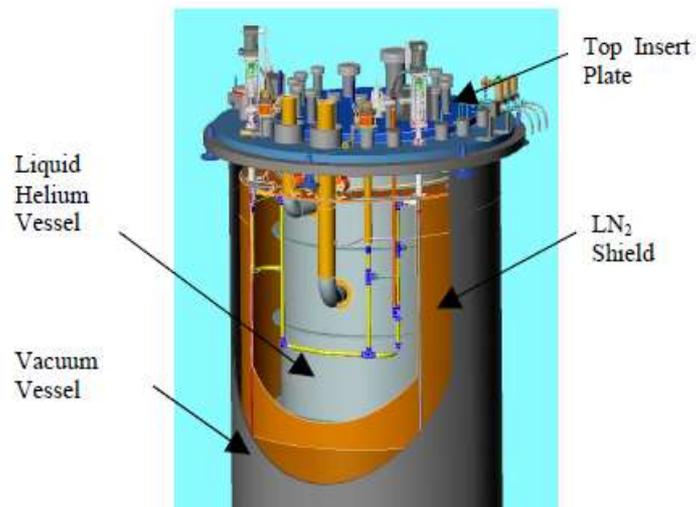
**Cyclic Compressor**

# Cryogenic facility

Jumbo Cylinder cascades: Helium gas evaporated from 10,000 liters of liquid helium can be stored in these cylinder banks at 140 bar.



# Vertical Test Stand (VTS) Facility for Cavity Qualification



Schematic of VTS cryostat assembly



VTS cryostat & cavity insert assembly



1.3 GHz 500 W RF source



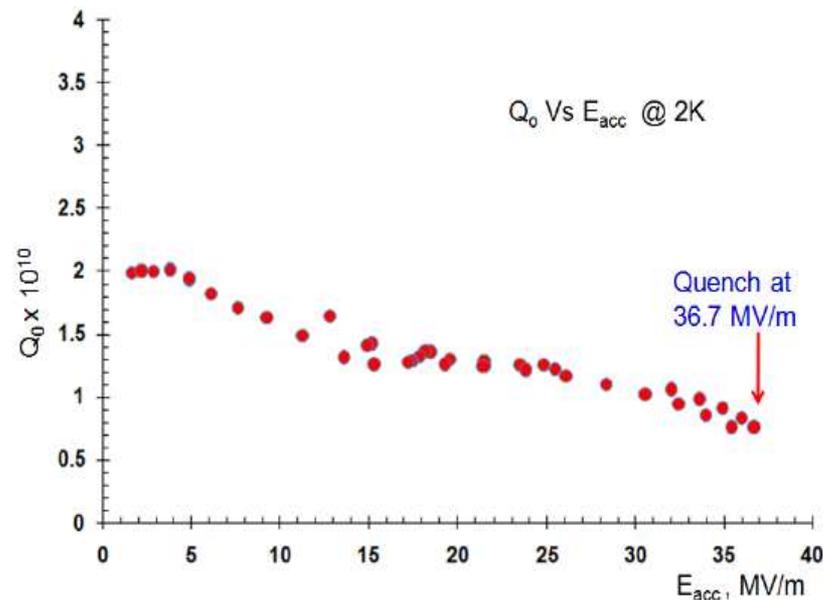
RF Control GUI

# Vertical Test Stand (VTS) Facility for Cavity Qualification

A vertical test facility for RF characterization of SRF cavities at 2 K has been commissioned. A single-cell 1.3 GHz cavity has been successfully tested using the facility.

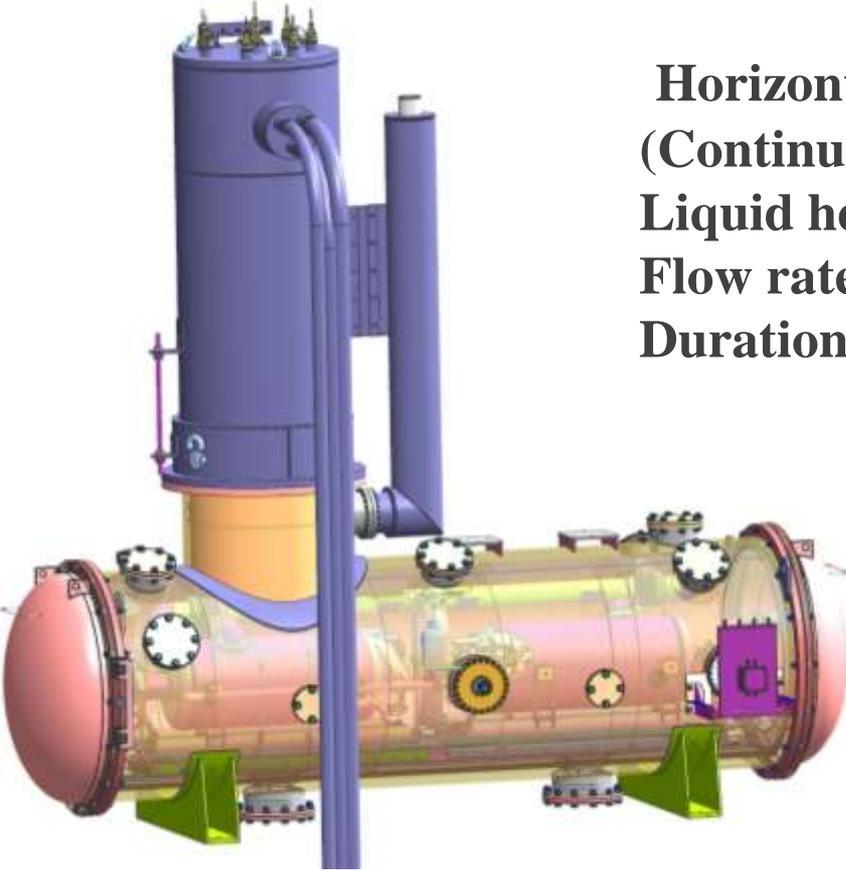


Transfer of liquid helium in the VTS cryostat



Testing of single-cell 1.3 GHz SRF cavity in the VTS facility at RRCAT

# Horizontal Test Stand for testing SCRF Cavities at 2K



## Horizontal Test Cryostat

(Continuous flow type cryostat)

Liquid helium requirement for each test: 3000 lit

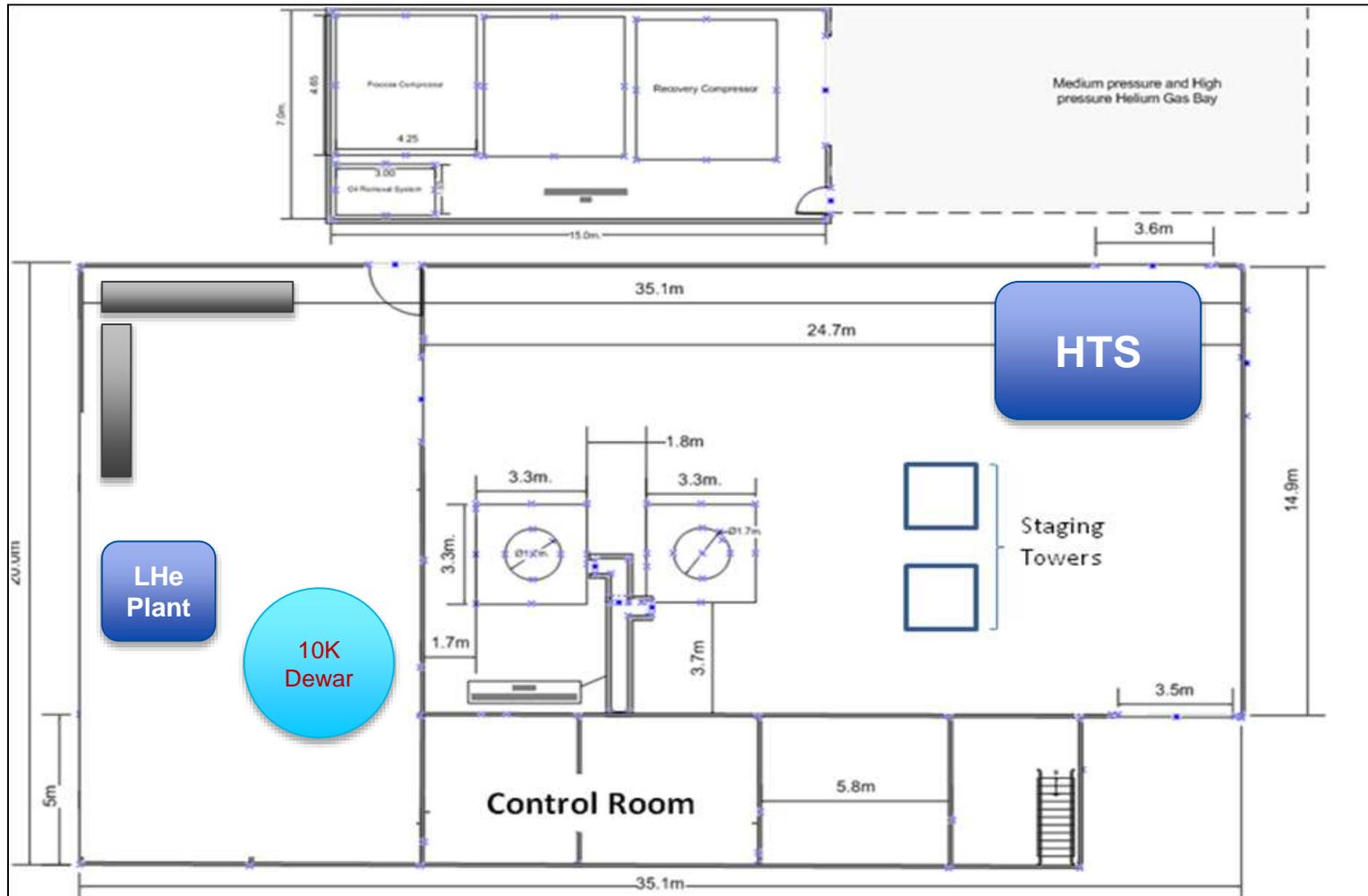
Flow rate: 6 g/s, ~ 115 W @ 2K

Duration of Tests: Two cool-down per month.

Horizontal test stand cryostat has been designed under IIFC.

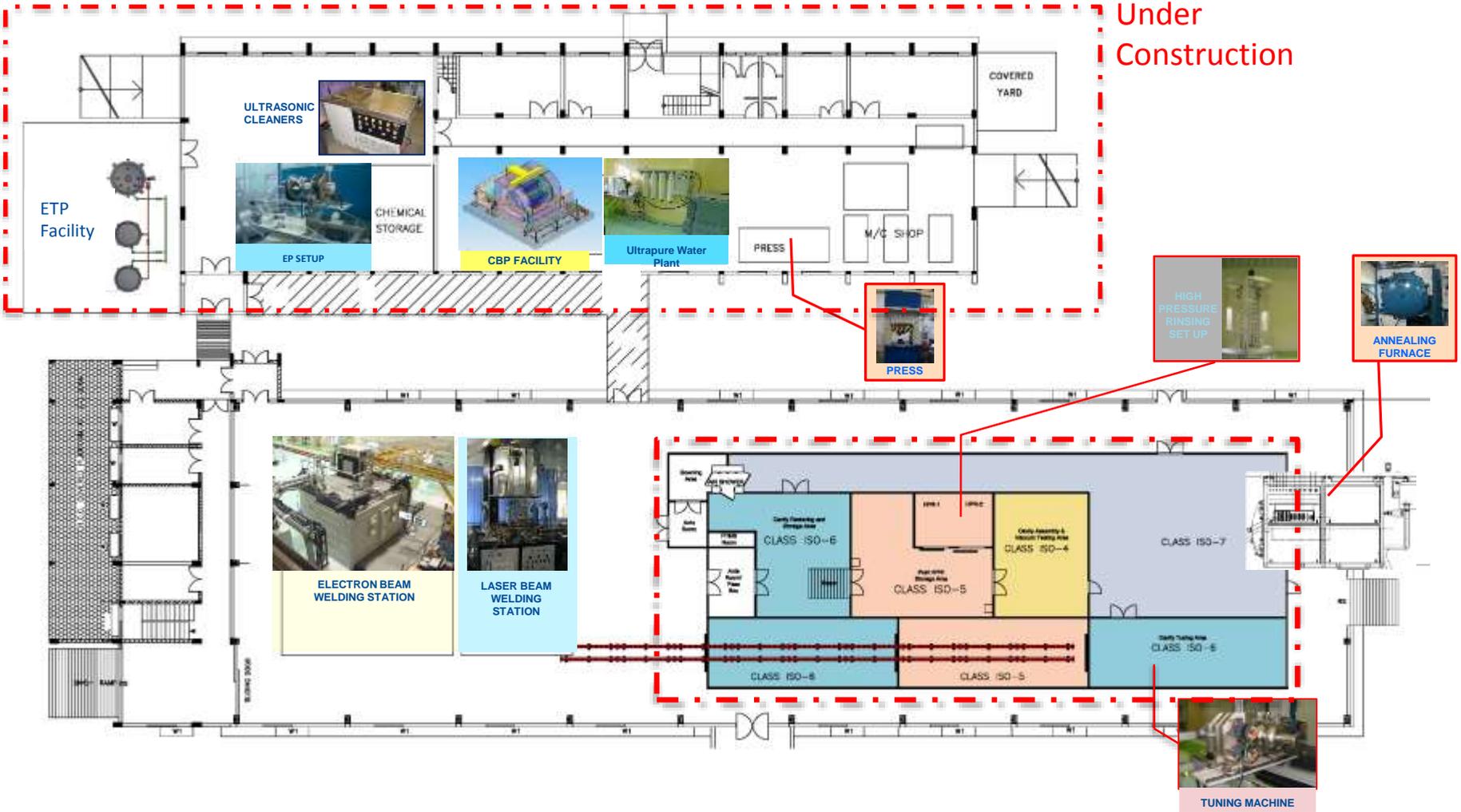
Procurement of the HTS cryostat is under progress.

# Building for SRF Cavity Test Facility



Layout of the cavity test building

# Existing & Planned Facilities



# Plans ahead ....

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- Commissioning of CBP machine for 650 MHz cavity
- Setting up of LTB facility
- Integration of new LHe Plant with VTS facility
- Development of tuning machine for 650 MHz cavity
- Setting up of class 10 clean room
- Shifting of EP facility in processing building
- Development of glove box for HB650 cavity dressing
- Fabrication, assembly, testing and integration of HTS
- Many more to come.....

**THANK YOU**